

Cool Community Program School & Community Partners Scientific Research Protocol

An Urban Heat Island Initiative project sponsored by the U.S. Environmental Protection Agency, the National Aeronautics and Space Administration and the U.S. Department of Energy

Air Temperature Measurement

Why we need to measure temperature

We as scientists want to understand how and where higher temperatures produce higher levels of ground level ozone and how these contribute to the urban heat island effect. Ground level ozone is an air pollutant that cannot be seen but contributes to lung problems such as asthma, emphysema and lung cancer in a number of U.S. cities including Sacramento. Ozone formation occurs primarily during the months from May through October. Sacramento ranks the 8th worst in air pollution in the nation.

We need to better understand how air temperature increases and decreases throughout the day in different areas and how this may influence ozone production.

We want to measure how different neighborhoods and arrangements of buildings, parking lots, roads and greenery contribute to the urban heat island effect. Some areas like downtown have many large office buildings and parking structures close together. In other areas there are large office parks with office buildings spread out with large parking lots around them. In some parts of Sacramento homes are close together with large older trees shading the streets and yards. In other neighborhoods homes are more spread out, streets are wider and trees are smaller.

In Los Angeles, ozone levels frequently reach unacceptable levels at or above 94°F Fahrenheit.¹

The temperature measurements taken by school and community partners will verify the temperatures indicated by the different colors on the infrared photographs taken by a remote sensing camera mounted on a NASA Lear jet during the same time period.

Overview

Briefly, we want to obtain two sets of temperature measurements taken simultaneously at four different locations on the school grounds every five minutes for a three and a half hour period between 10:30 and 2:00 p.m. The first set of measurements will be taken at three feet off the ground and the second set with the temperature probe two inches off the ground at the same spot. A total of 24 readings will be taken each hour at each site totaling 84 temperature measurements per site for the 3.5 hour period.

Management of the project

Effective local organization, strategic orientation and attention to detail are the critical points to achieve good results. We suggest that each site design a plan that fits the resources available at that location. Generally teachers should be the primary coordinators for their respective classes.

Number of researchers needed

It is important to plan to assure that all measurements are taken, every five minutes, for three and a half hours. The exact procedure is something the teacher and students can plan. It could involve a few as 12 students. Students can take turns making the four simultaneous measurements every five minutes. Students could work as teams, one noting the measurement and the other recording it, for each site. Teams could take turns after a specified time period of recording temperatures. Bathroom and lunch breaks need to be considered.

If you don't have four people, take the four measurements as close to the same time as possible and

document this deviation on the data sheet or an attached sheet.

Equipment needed for each site

The following materials will be supplied to each teacher by a member of the Cool Community Steering Committee or by the Cool Community Coordinator.

- Four digital thermometers will be supplied for each class that is participating.
NASA is supplying schools with the Radio Shack Indoor-Outdoor Thermometer, Model 63-1009. (\$15.99. Battery not included.)
- Spare AAA battery for each thermometer. (AAA battery 2-pack is \$1.79 at Radio Shack)
- Data record sheets

The teacher in charge or community cooperator will have to supply the following:

- A half-dozen styrofoam cups; the six ounce size is preferred
- Tape: transparent, masking, or four pieces of duct tape to tape the temperature sensor to the cup
- A battery operated clock with a spare battery or a wrist watch
A spare timepiece would probably be a good idea
- Wooden or plastic yardstick
- Camera, roll of color print film. It isn't required, but would be probably useful in documenting the effort to take snapshots of each step of the collection method, as well as a couple of long distance photographs to show the area and its surroundings.

Preparation of the Equipment

- The 2" by 3" thermometers have a ten foot cord attached with a tiny white rounded plastic sensor at the end. It is the white rounded probe that senses the temperature. It should be mounted in the cup by making a tiny hole in the middle of the bottom of the cup and gently forcing the probe through. It should extend just far enough in so that when the cup is turned upside down and placed on the ground the probe is two inches off the ground. Draw a line around the cup two inches from the open edge, then place the sensor just the right distance in with the ruler, then tape the cord on the bottom to hold it in place.



The purpose of the cup is to shield the sensor from the direct sun to improve measurement accuracy.

- After installing a fresh battery, flip the switch on the back of the thermometer to "C" so the readings will be recorded on the data sheets in centigrade, the metric temperature scale often used in science.
- Flip the button near the digital readout window to the OUT position, which tells the thermometer to use the probe to measure the temperature.

Method

- One person should be designated to call out the times at five minute intervals.
- We would like each of four sets of measurements (first three feet above the ground and second with the cup upside down on the ground) to be taken as close to the same time as possible to improve accuracy. If you don't have four students, take the four measurements as close to the

same time as possible and document this deviation on the data sheet or an attached sheet.

- The thermometers delay ten seconds before displaying a new temperature after being moved. After taking the first set of four simultaneous measurements, lower the cup to the ground and wait 15 seconds before taking the second simultaneous set of measurements. Write the exact time of the measurements on the data sheets.
- Remember that the purpose of the cup is to shade the sensor from the sun, so when taking the three foot reading, hold the cup upside down then too.
- Design a way to assure the accuracy of the height of the three foot measurement with the probe suspended in the air.
- What should be done if something disrupts the orderly recording of measurements? Describe the measurement problem for that time period on the data sheet briefly and proceed taking measurements with the next five minute sequence. Lunch or other breaks don't qualify as a reason for missing the measurements sequence.

Four Measurement Locations

1. In the sun over an impervious surface. A paved macadam or cement road, parking lot or paved playground would both qualify. Note the type of impervious surface on the data sheet.
 2. In the shade over (the same or nearby) impervious surface.
 3. In the sun over a vegetated area. It could be a garden, a mowed grass area, or a wild unmowed area. Note the type of vegetation on the data sheet.
 4. In the shade over a the same vegetated area.
- Measurements should be taken at least three feet away - probably more, say twenty feet - from the edges of surfaces, in order to get away from a "heat island" or "cool island" effect from one surface in relation to another.
 - Because the smallest objects that can register on the NASA infrared photographs measure approximately thirty feet across, pick areas that are larger than this in both dimensions, so we'll be able to identify the spots on the infrared photos. Sidewalks aren't wide enough.

Sequence of measurements

- For each of the areas listed above two sets of measurements should be taken.
 - One with the sensor suspended three feet over the ground.
 - Then drop the cup down and take the next measurement with the cup upside down on the ground so the sensor is suspended about two inches above the ground. Wait 15 seconds to read the ground level temperature
- Measurements should be taken every five minutes during the overflight period from 10:30 a.m. to 2:00 p.m.
- All measurements should be recorded in degrees centigrade and reported on the data sheet.

Return of the data sheets and digital thermometers

- Return the original data sheets, digital thermometers to the Sacramento Tree Foundation, 201 Lathrop Way, Suite F, Sacramento, CA 95815. (916) 924-8733

Cool Community Program School & Community Partners

Scientific Research Protocol

An Urban Heat Island Initiative project sponsored by the the U.S. Environmental Protection Agency, the National Aeronautics and Space Administration and the U.S. Department of Energy

Ground Level Ozone

Why we need to measure ozone

We as scientists want to understand how and where higher temperatures produce higher levels of ground level ozone and how these contribute to the urban heat island effect.

According to the American Lung Association,¹ ozone air pollution represents a serious and widespread public health problem. Ozone is formed by the action of sunlight on carbon-based chemicals known as hydrocarbons, acting in combination with a group of pollutants known as oxides of nitrogen. Hydrocarbons are emitted by motor vehicles, oil and chemical storage and handling facilities, and a variety of commercial and industrial sources such as gas stations and dry cleaners.

Ozone acts as a powerful respiratory irritant at the levels frequently found in most of the nation's urban areas during summer months. Symptoms include shortness of breath, pain when inhaling deeply, wheezing and coughing. Tests carried out on healthy adults and children under heavy exercise have found that exposure to ozone at a level equal to the current federal health-based air quality standard of 0.12 parts per million results in a decrease in normal function of the lungs.

Ozone formation occurs primarily during the months from May through October.

Equipment needed for each site:

The following materials will be supplied to each teacher by a member of the Cool Community Steering Committee or by the Cool Community Coordinator.

- Eco Badge Kit which contains ozone badges, paper filters and a color chart for measurement interpretation in parts per billion. The paper filter changes colors in presence of ozone - the more ozone, the more change in color.

- Data record sheets

The teacher in charge or community cooperator will have to supply the following:

- Timepiece



Description of the most useful type of site:

- All measurements should be taken outside in an area removed 100 feet from car, bus or other vehicle fumes and traffic. The same location should be used for each ozone measurement.

Number of researchers needed for each site:

- It is likely that one person or student, or a small team, could handle this.

Three measurements at one location

- The ozone filters or filters in badges should be pinned or placed three feet off the ground during the hour the filters are exposed.
- Measurements should be recorded three times during the overflight period.
 1. The first should be recorded at 10:30 a.m.
 2. The second at 12:00 noon
 3. The third at 2:30 p.m.
- At the time for recording each measurement, remove the filter from the EcoBadge, mark the time date and location on it using a ball point pen, and replace it in the airtight plastic holder following the instructions carefully to remove air from the airtight holder and seal it completely.
- Use the ozone paper color reader from the EcoBadge kit to translate the filter color into a corresponding ozone concentration. Have two or three people agree on the color so we don't have a color blind person taking the reading. Record the measurement on the data collection sheet in parts per billion.
- To take ozone measurements :
 - At 9:30 a.m. insert a paper filter in the badge
 - Place the badge WHERE?
 - At 10:30 a.m. remove the filter and place it in a plastic badge to stop the reaction. Follow the sequence described above.
 - At 11:00 a.m. insert another paper filter in the badge.
 - Place the badge in the same location as before.
 - At 12 noon remove the filter and place it in a plastic badge to stop the reaction. Follow the sequence described above.
 - At 1:30 p.m. insert another paper filter in the badge
 - Place the badge in the same location as before.
 - At 2:30 p.m. remove the filter and place it in a plastic badge to stop the reaction. Follow the sequence above.

Return of the data sheets and EcoBadges

- Return the original data sheets and unused materials from the ozone EcoBadge kits to the Sacramento Tree Foundation, 201 Lathrop Way, Suite F, Sacramento, CA 95815. (916) 924-8733

Interesting students experiments can be conducted

Gary Short, President of Vistanomics, Inc., the creator of the Eco Badge kit, reported that students have done many interesting experiments with the badges. One fifteen-year-old conducted an experiment to test her thesis that ozone readings would become lower as distance increased from a freeway. She was correct. Short said that more information about this experiment and others could be found on his company's web site at **www.ecobadge.com** in the contest section.

He also pointed out that the paper filters do not have to be placed in the Eco Badge holders. They can be taped or pinned up where required by the experiment being conducted.